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# The Design and Evaluation of an activity monitor for persons with Chronic Heart Failure

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## Introduction

In 2004 Chronic Heart Failure accounted for over 105,000 deaths in the United Kingdom [1]. For sufferers of CHF, factors such as poor diet and lack of exercise can increase the risk of further complications.

In this paper we outline the design, development and evaluation of a smartphone based activity monitor for persons with CHF. This application is a component of the SMART2 Project's Personalised Self-Management System (PSMS) [2]. Given that exercise training has become a valid treatment modality for CHF, focusing on endurance exercises in the form of walking and cycling [3], the proposed application has focused on measuring walking exercises.

## Materials and Methods

Functional requirements were elicited from two focus groups, one consisting of five healthcare professionals in the area of CHF and the second with eight CHF patients. The output from the focus groups identified, based on established research, walking as a goal target type, specifically time walking, and that an assessment of this activity be included. Increments in levels of activity are also required for the end user to assist them in increasing their exercise tolerance in order to achieve their overall goal. The focus groups also indicated that one area for future assessments may be to include a rate of perceived exertion (Borg Scale) [4].

There are three ways to measure a walking based exercise goal; amount of time, distance walked and number of steps. For each of these an individual piece of currently available technology may be required to measure accurately. Time spent walking can be measured using a simple stopwatch, distance can be measured using GPS hardware and steps taken can be measured using a pedometer. In this study, the proposed solution aims to leverage service delivery through a form of everyday technology which the user may have and hence avoid the requirement for an additional piece of equipment. The solution avails of in-built hardware that comes as standard in the HTC Touch HD running Windows Mobile 6.1. The HTC has a 3.5 inch resistive touchscreen, and four front facing hardware buttons (Pickup, Home, Back, Hang Up). Sensors include accelerometer and GPS. This device can support the measurement of each of the aforementioned parameters..

The user interface (UI) was designed to be as user-friendly as possible. The homescreen consists of three buttons, Phone, SMS and Goals. Each span over 75% of the screen width and 20% of the screen height, allowing accurate button presses and a large 'hit area'. Each button has both an icon and text to denote functionality. Customised WiFi, signal strength and battery level indicators have also been included in the UI and are larger than the native OS indicators. When the four hardware buttons are pressed these buttons, by default, enter the native OS and hence making it difficult for the user to re-enter the application. These have been disabled within the application.

By harnessing the vibration hardware we are also able to provide haptic feedback to the user when they interact with the device. Previous studies have demonstrated the benefit of this type of multimodal feedback whilst using mobile devices and hence in the current application adds a third feedback modality to the device along with visual and audio alerts.

The UI for the activity monitor (goal) component of the application uses a 'glancable' flower metaphor [5]. This provides the user with an ever-present interface whilst undertaking a goal-based activity. The application uses a simple algorithm that factors in the users weight, to ascertain a step count based on the in-built accelerometer within the phone. To date, this approach has achieved an accuracy of  $\pm 5$  steps when compared to an independent visual count. Figure 1 shows the process of performing an activity goal.

In addition to monitoring steps, the application can also detect inactivity and alert the user to resume an activity after a preset amount of time. The goal target is programmatically divided in two to obtain

a halfway value as well as eight increments. When each of the eight increments is reached a petal will appear. When the halfway point is reached the user is instructed to return home.



Figure 1. The application flow from Homescreen – Warm Up – Activity – Assessment.

When the user has successfully completed their goal, the application will ask them to assess their goal, 'Too Much', 'Too Easy' or 'Just Right'. If they deem the goal as being too difficult, they can decrease the goal target. If on the otherhand they deem it to be too easy, it will increase the target and just right will make no change.

## Results

Designing a UI for a mobile device presents a number of challenges. Screen real estate is reduced and input methods need to be considered as well as the target cohort. We have designed the UI to require the minimum of input to perform tasks, while still maintaining maximum levels of possible multimodal feedback. Consideration has been given to button size, placement and colour, whilst trying to incorporate metaphors for added meaning. The system is currently being evaluated by CHF sufferers with the evaluation focusing on UI, usability, hardware acceptance and reliability.

## Discussion

This work has focused on the UI for a mobile device that acts as both as phone and activity monitor. The UI of the application means the end user will not have to use and navigate a number of native applications, but will have one application from which they can access all the features they would need. By using a smartphone as the platform from which walking can be measured we have dispelled the need for several separate sensors, whilst also using the smartphone's communications to act as a gateway for transmission of data. All of the above measurements and functionality are based on the results of the focus groups. Future work will involve the continued evaluation of the system with persons suffering from CHF and refinement of the solution based on user feedback.

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